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ON THE

NATURE OF INFLAMMATION.

BY

JAMES CAPPIE, M.D.,

EDINBURGH.

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On the Nature of Inflammation. By JAMES CAPPIE, M.D., Edinburgh.

It seems now to be generally admitted among pathologists that inflammation is essentially a form of abnormal nutrition, and in this general view of its nature we entirely agree. That the vital operations in the tissue inflamed are in the irst instance affected, and that the phenomena which mani-est themselves during the progress of the morbid action, are o be more or less directly referred to this derangement, we hink there can be little doubt. Such a statement, however, ives no explanation of the phenomena themselves. The uestion as to the exact manner in which nutrition is modi-ed when inflammatory action is set up still remains. Before he theory of inflammation can be considered as complete, it ust be determined what those intimate changes are which ccasion the phenomena by which its presence is usually re-ognised, or which are certainly known to result from its oc-urrence. Considerable diversity of opinion still exists in gard to these details, and in their investigation there is ill ample room for inquiry and speculation.

A theory on the nature of inflammation must then be sed on the assumed correctness of particular views on the ture of nutrition. The latter process must be carefully alysed before any satisfactory progress can be made in un-lding the nature of its abnormal forms. Nutrition itself is t a simple action ; it involves the co-operation of a variety agents, and is constituted by a comprehensive combina-n and succession of phenomena. These phenomena must minutely studied individually ; we must become acquainted th their conditions and healthy modifications, and know the alities and particular offices of the various structures and ents concerned in their production. The more extended l precise our knowledge is in these respects, the better lified shall we be to judge of the nature of deviations from healthy standard. Where obscurity rests on any point mportance, the theory of inflammation must remain, to a tain extent, imperfect ; but as physiology and pathology inseparably related, and the facts and principles of the are always illustrated by those of the other, the study he abnormal forms of nutrition may assist in confirming efuting particular views on those points of the healthy cess on which there is still some difference of opinion. moreover of the utmost importance, in regard both to healthy and abnormal forms of nutrition, that we be looking for further explanations in the proper direction. For this purpose it is useful frequently to review the nature and extent of our present actual knowledge; and the formation of theories, even in the absence of sufficiently conclusive data, assists in arriving at a knowledge of the truth, by stimulating the mind to the discovery of such facts as may test their correctness, and thus relations may be recognised which might otherwise have remained unobserved.

Nutrition has for its object the attainment and preservation of such a constitution in a part as fits it for efficiently discharging the duties it is destined to perform in the animal economy. We at present restrict the application of the term to that process by which the integrity of the texture is preserved, notwithstanding the infinitude of changes which are constantly going on in its ultimate structure. We will not at present dwell minutely upon all that is known of its constituent phenomena, but will simply glance at those points which may afford assistance in forming correct conclusions in regard to the nature of inflammation.

For this purpose nutrition may conveniently be regarded as constituted by three series of phenomena. These are, in the first place, the changes in the ultimate structure of the tissue; secondly, the movement of blood in the capillaries; and lastly, the interchange of fluids between these vessels and the intervascular spaces. Something positively certain, or highly probable, is known respecting the conditions and healthy modifications of each of these sets of phenomena. Having specified some particulars regarding each of them, we must make it our object to discover in what manner they are affected individually, or in what respect their combination or succession differs, in the state of inflammation, from what occurs in the progress of healthy nutrition.

The changes presented in the ultimate structure of the texture are all more or less immediately connected with the growth, transformation, decay, and reproduction of cells. At any particular moment these are to be found in all stages of development. For the evolution of that progressive series of changes which constitutes their life as individuals, the principal condition is the presence of a fluid capable of furnishing them with the requisite materials of growth, and this is fulfilled by the blastema in which they are bathed, and which has been derived from the capillary bloodvessels. On this fluid important changes are effected by any progress in the development of the cells. Some of its elements are removed by those in a state of growth; while other cells, having arrived at the term of their existence, break up and restore to it, in a different form of combination, the elements they had previously separated. Circumstances are thus occasioned unfavourable to the growth of new germs. These, with a constitution similar to that which belonged to the parent cells, will be unable to separate the requisite materials of their growth, unless they are to grow differently, and have a different destination.

Looking at the texture as a whole, an important change is soon effected on its constitution by the simple evolution of these changes. As the former constitution, however, was the essential source of its functional power, some means must be provided by which every change may be remedied, and the integrity of the texture preserved. The worn-out particles must be replaced by others capable of being affected by the same influences, and of producing similar results. What is immediately required for attaining this end, is the removal of those products which result from decay, and the supply of fresh nutritive material.

The removal of effete matters, and the introduction of the necessary plastic elements, are made mutually subservient to one another. The attainment of these two objects is accomplished by one process. The fluids containing the respective elements being only separated from one another by the thin wall of the capillaries, endosmosis and exosmosis must immediately take place. The albuminous fluid within the capillaries will thus pass outwards into the intervascular spaces, while the fluid in the latter, loaded with the products of decay, passes into the vessels. Simultaneous interchange akes place among the gaseous ingredients, so that oxygen and carbonic acid mutually replace one another.

This interchange having been effected, the inherent tendencies of the growing cells are permitted to develop them-elves. The new supply of plastic material is at once the timulus and condition of growth, and the least progress in his again immediately involves the occurrence of the former hange in the blastema. A necessity hence arises for also onstantly renewing the fluid in the capillaries, and this is ccomplished by the unceasing current of the circulation.

The principal circumstance in connection with the capillary rculation which we would at present call to mind is its in-mate relation to, and dependence upon, the vital operations the ultimate structures of the texture. The rapidity of its urrent, or the quantity of blood made to flow through the ssels of any part, is not altogether dependent upon the rate vigour of the heart's action. The occurrence of certain anges in the parenchyma, and of a mutual action between the fluids within and external to the vessels, is a most necessary condition to the free transmission of blood through them. When nutrition is depressed, or its operations cease to be evolved, the current of the circulation is also interrupted, or it becomes completely stagnant. It is also well known, that when the nutritive changes are being carried on, a force is exerted at the capillaries by which the movement of blood is occasioned independently of any force acting on it from behind.

The final cause of this circumstance is sufficiently obvious, The object of the circulation being to act as a stimulus in various vital processes, and to afford materials for the formation or regeneration of the textures, there must be some means of so regulating its supply, that while this shall be sufficient for the wants of the texture, it will not be so great as, by its bulk or otherwise, to interfere with the proper exercise of its function. While the general current of the circulation, therefore, is sustained by the action of the heart, its local distribution must be regulated by other influences. Those changes which are the occasion of the demand in particular organs must involve the means of modifying the supply. The more actively the operations of nutrition are being carried on, the greater is the necessity for a free supply of nutritive material being provided. Whatever causes the growth of the cellular elements to take place more rapidly, will have the effect of sooner exhausting the supply, or changing the constitution, of the surrounding blastema. The activity with which the function of a part is being exercised exerts considerable influence on the occurrence of this change. Certain of the organic particles of which its structure is ultimately composed, may be regarded as instruments by the co-operation of which its function is discharged. The use of these instruments involves their wasting, and consequent unfitness for longer performing the duties devolving upon the tissue. The greater the energy with which they are exercised, the shorter will be their term of existence, and the more rapid therefore will be the change effected on the constitution of the fluid in which they are bathed, and into which they are a last dissolved. In these circumstances increased facility must be afforded for providing means by which they may be replaced,—the materials of growth must be supplied in greater abundance, and the products of decay more rapidly removed.

The immediate agency by which this result is attained i very complex, and our knowledge of its operation obscure; bu as the local vascular disturbance is one of the most remark able phenomena characteristic of the earlier stage of inflammation, it would be of importance, in order to account for that disturbance, to form an approximate notion of the mode in which the operations of nutrition can at all affect the movement of blood in the capillaries.

As it is necessary for this purpose to have recourse, for the sake of illustration, to those physical phenomena which present the nearest analogy to the one under consideration, it must be remembered that no mechanical ingenuity can construct a combination of circumstances at all approaching in intricacy the ultimate structure of any of the textures; nor, assisted by the most intimate knowledge of chemistry, can produce a combination and succession of changes such as are there presented. The minuteness of the structures, and the great variety and delicate nature of the changes, as well as the inconceivable rapidity with which they are effected, render it impossible for the mind to follow minutely all the steps and combinations of the process, or to trace with precision what relation any particular effect bears to some preceding step or combination. Our knowledge must be very general, and even in giving expression to this, a lengthened narration is sometimes necessary to describe what, in its actual occurrence, would occupy an almost inconceivably short space of time.

In physical science, the phenomena of capillary attraction, and those of combustion, afford instances of a current of fluid being produced independently of the influence of gravitation, or any obvious mechanical arrangement. The conditions on which nutrition is carried on may be regarded as involving a combination of the causes which operate in these two instances. Among the phenomena of capillary attraction, the particular fact that one fluid having a strong attraction for the walls of a capillary tube, will drive before it another fluid having a weaker attraction,[1] must especially be kept in mind when we would attempt to explain those of the capillary circulation. In the latter case, however, the capillaries themselves may be regarded as almost perfectly neutral, and as taking no active share in causing the movement of the blood. The attraction of their walls may be regarded as equally strong for arterial or venous blood. They may therefore be left out of view, and the relation of their contents to the fluids and solids external to their walls alone attended to. We have already seen how the constitution of the blastema in the intervascular spaces s soon altered from the action of the growing and decaying particles. It would constantly tend, in consequence, to become more widely different in constitution from the fluids within the vessels, if these were completely separated from one another. Being only separated, however, by a thin membrane, the physical phenomenon of interchange must, according to certain laws, immediately take place. Each gives up to the other certain of its constituents, so that they again come more nearly to resemble one another in composition. This will continue so long as the vital operations go on in the intervascular spaces, and as far as endosmosis and exosmosis will permit. If the supply within the vessels were limited, the vital changes would soon become suspended, just as combustion will become extinguished if the supply of oxygen be exhausted. But as in the latter instance the physical changes occasioned by chemical union serve, in ordinary circumstances, to bring a fresh supply of oxygen within the sphere of action, so the operations of nutrition involve in their performance the means of renewing the supply of blood in the capillaries. In combustion, the expansive repelling force of the heat acts equally on the constituents of the air and the carbonic acid which results from chemical union. But while the latter is simply repelled, the atoms of the burning body in immediate contiguity with those in the act of chemical union, attract the oxygen with greater force than the heat repels it. A perpetual agitation is thus kept up in the surrounding medium, and if oxygen be obtained with greater facility from one quarter, a current will be occasioned by which the gaseous products of combustion will be carried away in the opposite direction. In like manner, in nutrition the growing particles may be represented as keeping up a constant agitation in the medium by which they are surrounded, which extends itself, so to speak, into the capillary vessels. Within these, however, it is only from one direction that a fluid can be obtained with which the phenomenon of interchange can be readily effected. If now we suppose this tendency to interchange to be equivalent to the simple force of attraction in rigid capillary tubes, we may obtain a tolerably precise notion as to the manner in which a constant current may be sustained in the vessels. So soon as interchange has been effected to the smallest extent at any point, the tendency to its further continuance must immediately become diminished, but in regard to the fluid at an insensible distance behind it, in the direction of the arteries, this tendency is increased. To use a convenient form of expression, but not strictly precise, we may say, that when interchange has taken place, the attraction of the fluid in the intervascular space for the blood within the capillary, becomes at that point weaker, while it is comparatively stronger for the blood at an insensible distance behind it. The latter must therefore drive the other onwards before it, and the same series of phenomena will continue to be repeated so long as conditions continue favourable. The vital operations constitute a constantly operating cause of change in the intervascular spaces, and the arterial blood presents a fluid capable of affording ready interchange, and of sustaining these vital operations. A constantly operating force is thus brought to bear upon the movement of the blood.

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[1] Draper "On the Forces which produce the Organization of Plants."

If the above representation be correct, we may conveniently look upon the *occurrence of interchange* as an immediate cause of the movement of blood in the capillaries. Whatever favours the occurrence of this phenomenon, will therefore facilitate the movement of blood, or increase the force of its current. If nutrition is languid, and the blastema is in consequence slowly affected, the mutual action between it and the blood will be less vigorous, and the circulation will be retarded. If, on the other hand, nutrition be excited, the conditions of interchange being more actively presented, it will take place with greater energy, and its influence on the circulation will be correspondingly increased—the blood will be more rapidly transmitted through the vessels.

Such, then, is an outline of the circle of phenomena by which the process of nutrition is constituted. Their order of succession and mutual dependence and reaction must be kept steadily in view when we would attempt to determine the nature of inflammation. As no theory of the latter process can be considered complete or satisfactory which does not involve an explanation of its most characteristic phenomena, we will begin by attempting to interpret some of these individually. It will be admitted that that theory is most likely to be correct which, while perfectly consistent with all established facts, serves in the best manner to account for the production of observed effects. If several of the latter may be traced to one modification of the ordinary process of nutrition, we may be warranted in regarding that modification to constitute the proximate cause of inflammation.

Of the various symptoms or effects occasioned by the presence of inflammation, we select two which are most invariably presented—1*st*, increased vascularity; and, 2*nd*, the increase locally, and in the general current of the circulation of fibrine. If the occurrence of these be explained in a satisfactory manner, the others—as heat, pain, swelling, &c. —may be easily accounted for.

When a part which has become the seat of inflammatory action can be made the subject of observation, the greatly increased and permanent redness, in consequence of a larger amount of blood in its vessels, is one of the most prominent physical alterations presented. The blood is moreover transmitted through its vessels with increased velocity. It is true that when the inflammation has arrived at a certain height, the current begins to move more slowly, and at last complete stagnation of the circulation takes place; and this we will afterwards attempt to explain. At first, however, the circulation is invariably excited in all the vessels of the inflamed texture; the amount of blood transmitted through them in a given time is increased. On the proof of this we need not dwell, as we believe these statements will not be called in question. "The whole quantity of blood," says Dr Alison, "returned by the veins from an inflamed part (as in the case of the hand), is found to be greater, and, when the inflammation is severe, to be three or four times greater, than that returned within the same time by the veins of the opposite sound organ." Moreover, "in parts which have no blood-vessels of their own, and yet which manifest certain of the signs or effects of inflammation, these generally, if not always, involve (as Mr Paget remarks) enlargement of the adjacent vessels, and especially of those from which the diseased structure derives its natural supply of nutritive material. Thus, in inflammation of the cornea, the vessels of the sclerotica and conjunctiva are enlarged; and in ulceration of the articular cartilages the same enlargement is seen in the vessels of the surrounding synovial membrane or subjacent bone."[1]

Here, then, is a phenomenon, obvious and constant, and standing in the relation of effect to the morbid action whose nature we would endeavour to discover. When inflammation is at all acute in any texture, the blood is attracted more powerfully towards it, and is transmitted through the vessels more rapidly than in health. When we remember the intimate relation of the capillary circulation to the vital changes in the ultimate structures of a texture, and that excitement of the circulation is one of the earliest obvious results occasioned by inflammation, it seems probable that to account for its occurrence would at once determine the earliest step of the process,—the first deviation from the healthy order of succession in the phenomena of nutrition.

In having recourse, for the purpose of illustration, to those instances of alteration in the local distribution of blood which take place as a condition of health, we must confine our attention to those instances where the cause is also local,—where changes occurring in the parenchyma of the part itself so influence the current of blood in the capillaries asto accelerate its movement. Now, in all instances where this is observed, it is associated with activity in the ultimate structures of the texture affected. This activity may, of course, manifest itself in many various ways. For example, if it be gradual and simultaneous in all the structures which enter into the constitution of the texture or organ, increase of bulk or hypertrophy will be occasioned. If the organ be one of secretion, the amount of matters separated by it from the blood will be increased. The question therefore immediately suggests itself—Are the phenomena of inflammation the evidence of a peculiar or unusual excitement in the operations of nutrition? We think they are, and it will become our object to determine more precisely the mode in which this takes place.

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[1] Brit. and For. Medico-Chirurgical Review, Jan. 1851.

As we have just seen, one of the modes in which excitement of the nutritive process (strictly so called) can manifest itself, is in hypertrophy. But what will be the result if the excitement be more confined to the cellular elements, and the destructive as well as constructive operations are carried on with greater vigour than usual? Here, we think, the excitement will manifest itself in the phenomena of inflammation. But to explain more fully how this can take place, we will take a glance at the other characteristic phenomenon we have mentioned—the increased production of fibrine.

We may remark, that this relation of the vascular disturbance to a previous excitement in the vital operations has already been insisted on by various authors, and especially by Dr Alison. But in regard to the nature of the excitement—in tracing what results it directly tends to develop, and in interpreting the other characteristic phenomena of inflammation—we believe our views will widely differ from those of other writers.

In blood of a healthy constitution, fibrine is present in the proportion of about 2 or 3 parts in the 1000; but when an acute inflammation is well established in any part of the system, the proportion rises to between 6 and 8 in the 1000, or even higher. It also accumulates sometimes to a considerable extent at the seat of inflammatory action. The intervascular spaces become filled, or the inflamed surface becomes furred over with it. There is, therefore, an absolute increase in the amount of fibrine in the system.

Before this increase can be accounted for, the nature of fibrine itself must be determined. How is it produced in the economy, or from what source is it derived? On this point, however, very opposing opinions are entertained by physiologists. While some regard it as one of the constituents of the blood, at the expense of which the solid textures are principally nourished; others suppose (and we think correctly) that "it is more connected with the decaying than with the formative stage of life, and is destined to be removed from the system by the organs of secretion."—(*Bennett.*) We cannot here enter into an examination of all the arguments which have been advanced in favour of or against either of these views. The opinion of Zimmerman, that it results from the disintegration of the tissues, has in this country been advocated by Dr Bennett and Mr Simon; while Dr Carpenter, as is well known, strongly insists on the correctness of the other view. The latter eminent physiologist, however, seems to have very considerably modified his views as to the destination of fibrine. He would now "limit its *histogenetic* value to a certain class of tissues, namely the gelatinous." Now if albumen be sufficient for the nutrition of the muscular and nervous textures, it is difficult to see what necessity there can be for its becoming more highly vitalized in order to afford nutritive material for the gelatinous tissues. The very minuteness of the proportion in which fibrine exists in the blood appears strongly to militate against the correctness of such a view. It is also a remarkable fact, that in those individuals whose blood contains a larger proportion of fibrine than usual the textures are most poorly nourished.

We will only add one argument to those which we have seen advanced by other writers in favour of the view that fibrine is a product of disintegration. Both comparative physiology and pathological facts seem to point out that the proportion of fibrine and red corpuscles in the blood bear an inverse ratio to each other. When one of these principles is present in greater quantity than usual, we may infer with tolerable certainty that the proportion of the other is diminished. This may not be invariably true, but it occurs with sufficient frequency to indicate that an important relation exists between these two constituents. In individuals in very robust health, and in carnivorous animals, the proportion of the red corpuscles is greater than the average in the human subject, and that of the fibrine is diminished; while in weak, scrofulous, chlorotic individuals, in leucocythemia, and in herbivorous animals, the proportion of the corpuscles is diminished and that of the fibrine increased. Now, on the supposition that fibrine is a product of decay, we think it may be shewn how its amount is in part related to that of the corpuscles as effect to cause. It is a substance destined to be excreted from the blood; but before this can take place its chemical constitution must be altered, especially by its combination with oxygen. As the red corpuscles, therefore, are the "oxygen carriers," the greater their proportion is in the blood the more readily will the fibrine be oxidized, and so made to assume a form in which it can with the greatest facility be removed from the system.

Assuming, then, that the principal source of fibrine is the disintegration of the textures, we may proceed to discuss the question how its increase as the result of inflammation is to be accounted for.

In regard to its accumulation at the seat of inflammatory action, it has, so far as we are aware, been universally taken for granted that it has been exuded from the capillary vessels. All writers on the subject, however much they may differ in interpreting the other phenomena of the process, seem to agree in regarding this as a matter of fact. According to Dr Bennett, "exudation is the essential phenomenon, the *sine qua non* of inflammation." Now, if exudation be really a *fact*, it will, of course, with the usual stubbornness of its genus, remain unaffected by any arguments of ours to prove the contrary; and it may seem not a little presumptuous to question what is so generally admitted. Still we cannot help thinking that this explanation of its local accumulation is erroneous. Various objections may be urged against it, and some arguments may be advanced in favour of the idea that it is directly elaborated by the structures external to the vessels, and that its increase in the general current of the circulation is secondary to the occurrence of its local increase.

If liquor sanguinis were exuded in inflammation, we should expect the proportion of fibrine in the blood to become diminished instead of being increased, as it actually is, to at least twice or three times its usual amount. Soon after the local signs or general symptoms have presented themselves, the proportion of fibrine in the blood is increased, and gradually becomes greater in proportion to the intensity of the process or the amount of tissue involved in it. If we rightly understand Professor Bennett, however, he regards this increase to take place only after inflammatory action has subsided. He says, "during the disintegration of simple cancerous and tubercular exudations, the animal matter broken down is again rendered fluid, repasses into the blood, and then constitutes that excess of fibrine detected by chemists."[1]

Now this view is surely inconsistent with fact. Other writers have always supposed that the increase in the general current of the circulation is almost simultaneous with the progress of inflammation, and we are not aware that any proofs have been advanced to shew this opinion to be erroneous. If the buffed and cupped clot be any indication of the presence of an increased amount of fibrine, then it is certainly presented when inflammation is acutely going on. "The augmentation of fibrine," says Dr Watson, "begins with the inflammatory process, increases with its increasing intensity, and diminishes as it abates. That it depends upon the inflammation and not upon the general febrile condition, is apparent from the interesting fact, that in idiopathic fever the proportion of fibrine in the blood is diminished."

Moreover, the rational explanation of the fact of its local accumulation is not in the least promoted by assuming the occurrence of exudation. The phenomenon would simply have to remain an ultimate fact; for it is impossible to form any conception of an efficient cause for its occurrence; or rather, our present knowledge is opposed to its probability. If in the healthy evolution of the nutritive process fibrine passes out of the intervascular spaces into the capillary vessels, in accordance with the laws of endosmosis, then neither simple excitement nor depression of the vital operations will be able to cause it to pass in the opposite direction. Neither can we conceive that any alteration in the physical condition of the capillaries can have any material influence on its occurrence. Vital attraction cannot be the cause, for fibrine is an effete matter. Or, if we are to adopt the views of Dr Carpenter and Mr Paget on the nature of fibrine and on the nature of inflammation,—that the former is "the most highly organized material of the blood," and that in the latter, "so far as the proper substance of the inflamed part is concerned, there appears to be decreased action, that is, decreased formation," —it must be explained how a larger proportion of the fibrine than usual can pass into the intervascular spaces, when there is a less degree of attraction for it than in health.

Even assuming the occurrence of exudation as a fact, what does it explain ? It does not in the least assist us in accounting for any of the other phenomena characteristic of inflammation. It cannot be the proximate cause of any of the observed effects, except swelling. Neither the vascular excitement, the heat, nor the tenderness manifested or experienced at the part, can be referred to it.

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[1] Monthly Journal of Medical Science, Feb. 1850.

As there is an increase in the absolute amount of fibrine in the system, we must look for the cause of that increase to the source from which fibrine is in the first instance derived. We may naturally expect some excitement to exist in the process by which it is produced.

Its principal primary source we have already considered to be the dissolution or disintegration of cells or fibres. Of the various elements into which these are resolved in their decay, fibrine is one; and it is therefore being constantly elaborated in all the textures. Let us for a moment suppose that its production is the final cause of nutrition,—that it is a secretion which, instead of being carried away by a channel of its own, must be received into the blood; if we were wishing to cause a circumscribed portion of any structure to produce fibrine in greater quantity than usual, we would simply require to adopt such means as would cause the changes of growth and decay to go on faster than usual. The instruments by which it is elaborated being thus, as it were, more vigorously exercised, they must be more rapidly worn out and reproduced. This will involve,—as in all other instances where an organ of secretion is stimulated,—not only as a condition for the continuance of the excitement, but, in the manner we have already attempted to explain, as a direct consequence,—the supply of a larger amount of nutritive material. The conditions of interchange being more rapidly presented, the mutual action between the blood and the tissues will take place with greater vigour; and, in conequence, the blood will be more strongly attracted to the part, and transmitted through the vessels with increased rapidity.

Now, we are inclined to think that this is actually what akes place in the first stage of inflammation; and we thus ee how its two most characteristic phenomena are the result of one action. To account for the increase of fibrine, we have rrived at exactly the same modification of nutrition which we assumed to be the immediate cause of the vascular excitement. If the manner in which we have attempted to trace these causes individually be a legitimate one, the coincidence ffords strong presumption in favour of the correctness of ur conclusions.

We need not here do more than allude to the satisfactory manner in which the increased heat and tenderness of the part may also be explained by the above view. If the vital operations are being carried on with greater rapidity, chemical changes must also be taking place with increased activity, and a greater amount of heat must in consequence be evolved. If the nutrition of the nerves be involved in the excitement, this will, with the consequent augmented vascularity, exalt their function, and render them more susceptible of impressions.

"Dilatation of the vessels" has been regarded as one of the most constant phenomena of inflammation. It seems to have been studied, however, more in relation to the effects it involves, than in regard to its immediate cause. The influence of greater or less *friction*, in consequence of diminished or increased calibre of the vessels, in affecting the current of blood, has been fully discussed.[1] But it must be remembered that it is the mutual action between the blood and the tissues which regulates the amount of nutritive fluid transmitted through a part; and therefore the changes in the physical condition of the vessels must be the effect, rather than the cause, of any alteration in the movement of blood. If the forces affecting that movement are acting with greater vigour,—if the current of the circulation be more rapid than natural,—then increased *pressure* must be exerted on the vessels, and this, of necessity, must tend to enlarge their calibre. A natural explanation of the occurrence of dilatation in the capillaries of, and arteries leading to, inflamed parts, is thus afforded on the supposition that excitement of nutrition exists in the latter.

The preternatural excitement in the operations of nutrition cannot long continue without involving most important consequences. The general rule, that the greater the rapidity with which any texture is formed, it is the more liable to degenerate, soon becomes well illustrated. The evidences of vitality soon become less marked, and at length, if the inflammation be severe, nutrition becomes entirely suspended. The current of the circulation first becomes languid, then oscillates, and at last becomes completely stagnant. These evidences of decay and death are, however, the natural and inevitable result of the excitement which characterized the early stage.

To account for the stagnation of the circulation, various theories have been entertained, and much discussion occasioned. No efficient physical impediment can be detected. There is no obstruction in the vessels themselves, and yet the cause must be a local one. We must here again consider the influence of the structures external to the capillaries.

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[1] See Jones "On the State of the Blood and the Bloodvessels in Inflammation," and Brit. and For. Med.-Chirurg. Rev., Jan. 1850.

As the increased vascularity of the early stage of inflammation was referred to an excitement in the operations of nutrition, so stagnation of the circulation,—so invariably presented during its later stage,—may result from these being in the first instance suspended. The current will thus be interrupted, not so much from the operation of any active cause, as from the mere absence of the force which occasioned the movement of the blood during the healthy state of nutrition.

It is difficult to give a very minute detail of the various steps by which this ultimate result is occasioned; but the following statement, which we give as a summary of our views on the nature of inflammation, may exhibit their possible order of sequence.

The primary effect of such a stimulus as excites inflammation is to disturb the balance of nutrition in the part affected. *The whole series of operations by which the simple integrity of the texture is preserved is evolved with greater rapidity than natural.* Growth, dissolution, and reproduction all take place with greater vigour than in health, or in comparison with their occurrence in the texture around the seat of inflammation. The attractive force for nutritive materials is rendered stronger than natural, and these are effused from the vessels in greater abundance. The constitution of the blastema is rapidly altered, and the interchange or mutual action between that fluid and the blood is carried on with great activity. The force by which the latter fluid is attracted to and transmitted through the vessels is thus acting more powerfully than usual. The current of the blood being more rapid, its pressure against the walls of the vessels must be greater, and thus dilatation of the capillaries, and of the arteries by which they are fed, is occasioned. Various circumstances, however, soon interfere with the occurrence of interchange, and the circulation in consequence begins to flag. Fibrine is one of the substances which are being produced in greater quantity by the excitement in the vital operations. In order that it may be able to enter the bloodvessels, it must be kept dissolved by a sufficient quantity of watery fluid. The effused serum, after it has given up its albumen to the growing cells, assisted by the more inorganic products of decay, supplies this desideratum in healthy nutrition. But *in inflammation the fibrine is elaborated with greater rapidity than it is being admitted into the vessels.* Its amount thus increases in the intervascular spaces, and in consequence it must soon interfere with the nutritive process—the vital operations will be depressed; the more inorganic compounds will pass more readily into the vessels than fibrine, and thus the exosmotic passage from these of serum will still be sustained. From this, in consequence of the momentum which nutrition has received, the germs and cellular elements will still strive to be developed, and thus the proportion of fibrine will continue to increase in the interstices of the tissue. As interchange becomes less vigorous, the current of the circulation will be transmitted more slowly. The globular constituents of the blood will accumulate in the capillaries, partly because the mutual action between these and the textures is less energetic, and partly because the fluid portion of the blood will be more readily affected by the action of the heart. When the vital operations are completely suspended, the blood will, as a necessary consequence, become stagnant in the capillaries. An attraction of simple cohesion, rather than a tendency to interchange, will be exerted between the fluids on either side of their walls.

One of the principal points, but a very important one, in which the above theory differs from those advanced by other writers on the subject, is in regarding the fibrine which accumulates at the seat of inflammatory action to be the result of direct elaboration, instead of exudation. If this view be correct, our notions on the nature of the healing process, and on the manner in which hemorrhage is checked, must be very considerably modified. We think, however, that the manner in which it may be applied in these instances affords corroborative evidence of its correctness.

When a solution of continuity has occurred in any texture, the circumstances in which nutrition takes place are greatly altered. They are brought more nearly to resemble those in which secretion is carried on. The conditions for effete matters being received into the vessels, are much less favourable than those presented in the ordinary circumstances of nutrition. The molecular elements will, from their own inherent endowments, and from the stimulus given by the mechanical violence, still strive to be developed, and this will occasion effusion of the serous part of the blood. But whether the raw surface be superficial, or two cut surfaces are approximated to one another, the products which result from the evolution of the nutritive changes cannot be received into the circulation with the facility with which this is effected in the healthy condition of the tissues. The more inorganic compounds will, however, enter the vessels, or be carried away in the discharge more easily than the fibrine, and thus the latter, accumulating at the surface, will afford it protection, or form a bond of union between two parts; it will prevent hemorrhage.

limit effusion, and permit nutrition beneath it to be carried on as usual.

If from the previously depraved character of nutrition, or from the nature or intensity of the stimulus, the nutritive operations are evolved in a manner different from natural, the formation of pus may be the consequence. But if nutrition has been healthy, and conditions are favourable, the growing molecules will be developed in much the usual manner, and thus union with the first intention may take place without any of the other phenomena of inflammation manifesting themselves. In the latter instance, the nutritive operations at the cut surface may be regarded as naturally tending to their own extinction. In the treatment of ulceration, it is our object to produce this effect, and the means employed must be adapted to the nature of the ulcer. While the healthy sore simply requires protection against the operation of injurious influences, the indolent ulcer requires the application of such substances as have an irritating influence, that is, which tend to the production of inflammation, and consequently to the formation of an increased amount of fibrine, or fibrinous structure. We need only allude, in confirmation of this view, to the remarkable effect of a blister in changing the action of the worst forms of indolent ulcer.

In regard to the pathology of hemorrhage, if extravasation of blood be checked by the coagulation of fibrine as it is escaping from the ruptured vessels, we should expect that in those instances when the proportion of that constituent of the blood is above the average, hemorrhage would be checked with the greatest facility. So far is this from being the case, however, that in some states of the system where this condition is present, the strong tendency to hemorrhage is one of the most remarkable characteristics attending it. In some cases of scurvy the proportion of fibrine in the blood, if we may judge from the "buffed and cupped clot" which is formed, is increased. But in leucocythemia this connection between the hemorrhagic diathesis and such a condition of the blood is most marked. In this affection the proportion of fibrine is almost invariably much above the average, and in twenty-five undoubted cases of it published by Professor Bennett "extravasation of blood occurred in fourteen." In one case where it is recorded that there was "no epistaxis at any time, no hemoptysis, a little hematemesis, no melæna, hematuria, nor menorrhagia," some leeches having been applied to remove a local pain, "the bleeding was profuse and not very easily arrested." Some other influence must therefore be in operation besides the mere coagulation of the fibrine of the blood itself, and this may be found in the vigour with which nutrition is being performed. If this process be languid, little hindrance will be afforded to the occurrence of extravasation; but if its operations be carried on with vigour, the elaboration of fibrine at the part will speedily be effected, and the mouths of the vessels be thereby closed.

We will not in the present essay give any account of the mode in which development or degeneration of the products of inflammation may take place. Neither will we enter into any examination of the constitutional symptoms, nor attempt to trace their relation to the local changes. It is sufficient for our purpose, in the meantime, if the theory we have advanced be not inconsistent with facts established in regard to these. We will therefore conclude for the present with a few remarks on the principles which must guide us in the treatment of inflammation.

A theory on any morbid process is important according as it affords a rational explanation of the mode in which remedial agents operate in checking its progress and removing its effects. We are inclined to think that the views which we have attempted to establish on the nature of inflammation will, to say the least, admit of as wide application in this respect as any of the more prevalent theories on the subject.

A slight review of the nature and relations of its various phenomena will serve to shew how every means which prevents the free determination of blood to the seat of inflammation, will tend to lessen its intensity and favour resolution. The local vascular excitement is, as we have already attempted to shew, both the consequence and condition of the process. The supply of blood is simply in proportion to the demand for it; therefore, a diminution in the amount of the former must inevitably interfere with the operations which occasion the latter. The development of the particles cannot be carried on with the same degree of vigour if the nutritive materials are less readily supplied, and thus an opportunity is afforded for the balance of nutrition being restored. If the excitement still tends to continue for a short time in the ultimate structures, the conditions of free and immediate interchange not being present, the products of decay will accumulate in the interstices of the tissue, and the vital operations being thus interfered with, the natural termination of the process is more speedily effected.

Although in their action on inflammation, some substances, such as opium or acetate of lead, may possibly have a directly sedative influence on the operations of nutrition, the majority of the means employed to arrest its progress seem rather to act by moderating the supply of blood to the parts affected. The influence of bloodletting must in this way be frequently very powerful in "disposing to a favourable termination," or even in "cutting short" the morbid action. The same end, however, may often be obtained by any means which simply cause a derivation of nutritive fluid from the inflamed textures. For example, tartar emetic, by acting on the skin and mucous membranes of the body, and causing in consequence a determination of blood towards these, will affect the general distribution of that fluid, and permit a less amount of it to be sent to the seat of inflammation. In like manner such means as act on particular organs of secretion, mercury, purging, blistering, &c., will often be useful. Without dwelling on these instances, however, we would rather attempt an explanation of the tonic plan of treatment.

"There are none," says Dr Alison, "who resist the exciting causes of inflammation so well as those in whom the blood is abundant, and the vascular system vigorous. But the tendency to inflammation is remarkably given by all permanent causes of debility; by imperfect nourishment, impure air, long-continued heat or cold, excessive evacuations, mental depression, excessive exertions, and intemperance." Now, in these instances we think the influence exerted does not so much increase the tendency of individual textures to inflame, as by diminishing the power of nutrition to preserve the equilibrium of the circulation, and therefore favouring the more free determination of blood to the seat of inflammatory action.

A constant antagonism is exerted between all parts of the body in their relation to the circulation. If A and B are supplied with nutritive material from one vessel or system of vessels, the amount which A will receive will not altogether depend upon the degree of its own attraction for it, but also on the intensity of the force operating at B, and on the facility, therefore, with which the latter will permit itself to be deprived of a portion of its supply. It is therefore not simply the amount of stimulus applied to an organ or texture which determines the amount of blood it will receive, and consequently the effect which will be produced on nutrition, but also on the degree of force required to derive it from other parts of the system. The readiness with which the latter can be deprived of their natural proportion of blood will have an important influence in aggravating or repressing the tendency to local excitement,—in favouring or counteracting the influence of the stimulus. If the operations of nutrition in the system generally be vigorous, the textures will with difficulty be deprived of their usual supply of nutritive fluid; but if nutrition be languid, and the attraction for blood in consequence feeble, the latter fluid will, with comparative facility, be determined in greater quantity towards any point at which operations causing a stronger attraction for it have been excited. This must be at least one of the reasons why in a debilitated constitution inflammation takes place with greater certainty than usual, on exposure to its exciting causes.

The object of treatment, then, must be to restore at once the balance of the circulation and that of nutrition. It comes to be a question, therefore, whether this is to be attempted by directly moderating the activity at the seat of inflammation, or by exalting nutrition in other parts of the body. It is obvious that bloodletting cannot often be trusted to for restoring the balance of nutrition. The loss of blood will have a depressing influence on this process in the system generally, as well as at the seat of morbid action. It may happen that at the latter part the operations are still *relatively* more active than in other parts, and thus inflammation may go on unchecked, or may even be aggravated.

In the majority of instances our object will be more efficiently accomplished by stimulating nutrition in other portions of the system. For this purpose it may be useful, as we have just seen, to act on particular parts; but if the same end can be attained by affecting nutrition generally—by rendering its operations more vigorous, and so increasing the attraction for nutritive fluid, then, not only will inflammatory action be depressed by the parts affected receiving a diminished supply of blood, but an important step will be taken in securing more speedy convalescence. In all cases where it is suitable, therefore, the latter course is certainly to be preferred. In erysipelas, pneumonia, or in almost any inflammation whatever, when the nutrition of the system has been depraved, the administration of tonics, as the preparations of quinine or iron, must in this way have frequently a most beneficial influence.

We think there exists considerable analogy between the *modus operandi* of tonics in the treatment of inflammation, and of quinine in the cure of intermittent fever. In the latter disease, the diagnostic phenomena are associated with, if not occasioned by, general disturbance in the balance of the circulation, and this, again, is connected with a weakened state of nutrition in the system. At the commencement of a fit of ague, a less amount of blood than usual is determined to the surface and extremities of the body, while congestion takes place in the internal viscera. Now, as there is no obvious physical or physiological cause for the occurrence of this phenomenon, and we are consequently ignorant of any action to subdue, or physical influence to counteract, the rational mode of treatment must be to adopt such means as will tend to preserve the equilibrium of the circulation. If, by the introduction into the blood of any substances having an irritating effect on nutrition, we cause that process to be carried on more vigorously, then, on the one hand, the attraction for nutritive fluid is rendered stronger, and the textures are deprived of their supply of blood with less facility; and, on the other, the tendency to passive congestion is counteracted. If in this way the simple equilibrium of the circulation be preserved, the characteristic phenomena of the fit of ague will be prevented from manifesting themselves. And such we believe to be the *modus operandi* of quinine and arsenic in its cure. They act on nutrition generally, and cause its operations to take place with increased vigour. They exert, we would suppose, an irritating, rather than a stimulating influence; that is, their influence is, in the first instance, directed on the ultimate structures of the texture, rather than directly on the circulation itself.

We need hardly remark, that if the exudation theory, when applied to the phenomena of inflammation, be inefficient and unsatisfactory, so neither can it afford an explanation of the formation of tubercle. This pathological product we regard to result from a combination of circumstances lmost diametrically opposed to those which occasion the henomena of inflammation. It is also a product of abnormal nutrition, but the process, instead of being excited, , in comparison with that of the texture around where is forming, materially depressed. The balance of nutrition is still disturbed, but here it is because that of the seased tissue fails to come up to the healthy standard. From the deficient nutritive or stimulating qualities of e effused blastema, the operations fail to be fully evolved. to this subject, however, it is not our intention to enter at esent.